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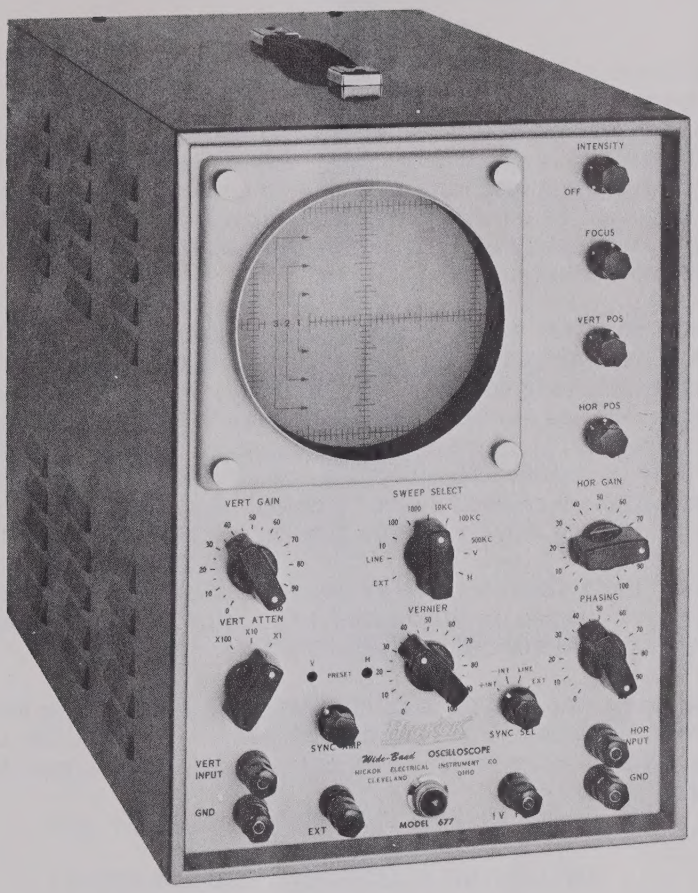
GENERAL ELECTRIC CO.
Instrumentation & Control
228 W. Florence Ave.
Inglewood, Calif. 90301

INSTRUCTION MANUAL

for

MODEL 677
"WIDE BAND" OSCILLOSCOPE

THE HICKOK ELECTRICAL INSTRUMENT COMPANY • 10514 DUPONT AVENUE • CLEVELAND 8, OHIO



MODEL 677

"WIDE BAND" OSCILLOSCOPE

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This warranty does not apply to any of our products which have been repaired or altered by unauthorized persons or service stations in any way so as, in our judgment, to injure their stability or reliability, or which have been subject to misuse, negligence, or accident, or which have had the serial number altered, effaced or removed. Neither does this warranty apply to any of our products which have been connected, installed, or adjusted otherwise than in accordance with the instructions furnished by us. Accessories, including all vacuum tubes not of our manufacture, used with this product are not covered by this warranty.

This warranty is in lieu of all other warranties expressed or implied, and no representative or person is authorized to assume for us any other liability in connection with the sale of our products.

Parts will be made available for a minimum period of five years after the manufacture of this equipment has been discontinued. Parts include all materials, charts, instructions, diagrams, accessories, etc., which have been furnished in the standard model.

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The above guarantee is contingent upon the attached registration card being returned to the factory immediately upon receipt of the equipment.

THE HICKOK ELECTRICAL INSTRUMENT COMPANY
Cleveland, Ohio

TABLE OF CONTENTS

SECTION 1--GENERAL INFORMATION

Paragraph		Page
1-1.	Description	1
1-2.	Instruction Manual Changes	1
1-3.	Specifications	1

SECTION 2--OPERATION

2-1.	Explanation of Controls and Connectors	3
2-2.	Sequence of Operation	5
2-3.	Specific Application	5

SECTION 3--CIRCUIT DESCRIPTION

3-1.	General	7
3-2.	Low Voltage Power Supply	7
3-3.	High Voltage Power Supply	7
3-4.	Vertical Amplifier	7
3-5.	Horizontal Amplifier	8
3-6.	Sweep Generator	8

SECTION 4--MAINTENANCE

4-1.	Operational Maintenance	9
4-2.	Adjustments and Calibration Standards	10

SECTION 5--PARTS LIST

5-1.	Introduction	13

LIST OF ILLUSTRATIONS

Figure		Page
	Model 677, Wide Band Oscilloscope	Title Page
	SECTION 1--GENERAL INFORMATION	
1-1.	Table of Electron Tube Complement	1
	SECTION 2--OPERATION	
2-1.	Front Panel Controls and Connectors	3
	SECTION 3--CIRCUIT DESCRIPTION	
3-1.	Tube Layout	6
3-2.	Block Diagram	7
3-3.	Tables of Voltage and Resistance Values	17
3-4.	Schematic Wiring Diagram	17
	SECTION 4--MAINTENANCE	
4-1.	Periodic Table of Maintenance	9
4-2.	Square Wave Adjustment	10
4-3.	Compensation for the Vertical Attenuator	11

SECTION 1

GENERAL INFORMATION

1-1. DESCRIPTION

The Hickok Model 677 is a wide band, general purpose oscilloscope designed to meet the needs of the radio and television serviceman in the shop or in the field. Its wide band characteristics permit portrayal of sinusoidal waveforms, non-sinusoidal waves of special shapes, such as square waves, etc. It provides the requisite range, stability and accuracy for precise measurement in the visual study of electrical phenomena such as modulation, phase relations, voltage amplitudes and distortions.

1-2. INSTRUCTION MANUAL CHANGES

Due to the Hickok policy of continued product improvement, sometimes engineering changes are made before they can be incorporated in the instruction manual. When this situation occurs an ammendment sheet and/or a new schematic wiring diagram will be added to this manual until such a time as a new manual can be printed. Thus you are assured that your information is up-to-date and applies to your particular instrument.

1-3. SPECIFICATIONS

a). Power Requirements---
117 Volts. 50 to 60 cycles

b). Power Consumption---
90 Watts at 117 Volts

c). Tube Complement

REF. SYMBOL	TYPE OF TUBE	FUNCTION OF TUBE
V1	1V2	High Voltage Rectifier
V2	6X4	Low Voltage Rectifier
V3	6C4	Voltage Regulator
V4	6C4	Vertical Input Cathode Follower
V5A	6AN8 Triode Section	Vertical Input Amplifier
V5B	6AN8 Pentode Sec.	Vertical Input Amplifier
V6A	12BH7 Triode Section	Vertical Output Amplifier
V6B	12BH7 Triode Section	Vertical Output Amplifier
V7	6DT6	Sweep Circuit Oscillator Multivibrator
V8A	12AU7 Triode Section	Sweep Circuit Oscillator Multivibrator
V8B	12AU7 Triode Section	Sweep Output Stage
V9A	12AU7 Triode Section	Horizontal Input Cathode Follower
V9B	12AU7 Triode Section	Horizontal Input Amplifier
V10A	12AU7 Triode Section	Horizontal Output Amplifier
V10B	12AU7 Triode Section	Horizontal Output Amplifier
V11	5UP1	Cathode Ray Tube

Figure 1-1. TABLE OF ELECTRON TUBE COMPLEMENT

d). Vertical Amplifier

1). Maximum Input voltage - 600 volts DC.
2). Passband---Flat to within 3db from 5 cycles to 4. 5 megacycles.
3). Sensitivity---40 Millivolts for one inch of deflection.
4). Input Impedance
Attenuator at X1---3 megohms shunted by 20 PF.
Attenuator at X10, X100---3. 3 Megohms shunted by 10 PF.
5). Rise Time---Less than 0. 08 Microseconds.
6). Attenuator---Three Step decade attenuator, X1, X10, X100, Frequency compensated.

e). Horizontal Amplifier

1). Passband---Flat to within 3db from 5 cycles to 350 KC.
2). Sensitivity (gain)---0. 25 volts (RMS) per inch.
3). Input Impedance---4. 7 megohms shunted by 30 PF.
4). Sweep Speeds---Frequency coverage from 10 cycles to 500 KC in five ranges, with VERNIER control from:

10 to 100cps
100 to 1000cps
1KC to 10KC
10KC to 100KC
100KC to 500KC

f). Calibrator

1). Provides a one volt peak-to-peak 60 cycle sinewave signal to calibrate the vertical amplifier for voltage measurements. (CRT graticule also calibrated in 1/10 inch divisions)

g). Sweep Generator

1). Frequency Range--- 10 cycles to 500 KC in five (5) steps, plus VERNIER control.
2). Synchronization--- Internal, positive or negative locking signal, self limiting circuit. Provision made for external sync input.
3). Retrace Blanking--- Positive retrace blanking regardless of sweep frequency.

h). Display

1). Five inch CRT. 1300 Volts Accelerating Potential, DC coupling to deflection plates.

i). Physical Characteristics

1). Weight--- 26 pounds net.
2). Size--- 18-5/8" long x 13 5/8" high x 9 1/2" wide
3). Color--- Hammer-Tex Blue

SECTION 2

OPERATION

2-1. EXPLANATION OF CONTROLS AND CONNECTORS

Before using Model 677 for the first time, study the explanation and use of the front panel controls and connectors as explained below:

The front panel controls and connectors are divided into four sections: Cathode Ray Tube Controls, Horizontal Amplifier Controls, Sweep and Sync Controls, and Vertical Amplifier Controls.

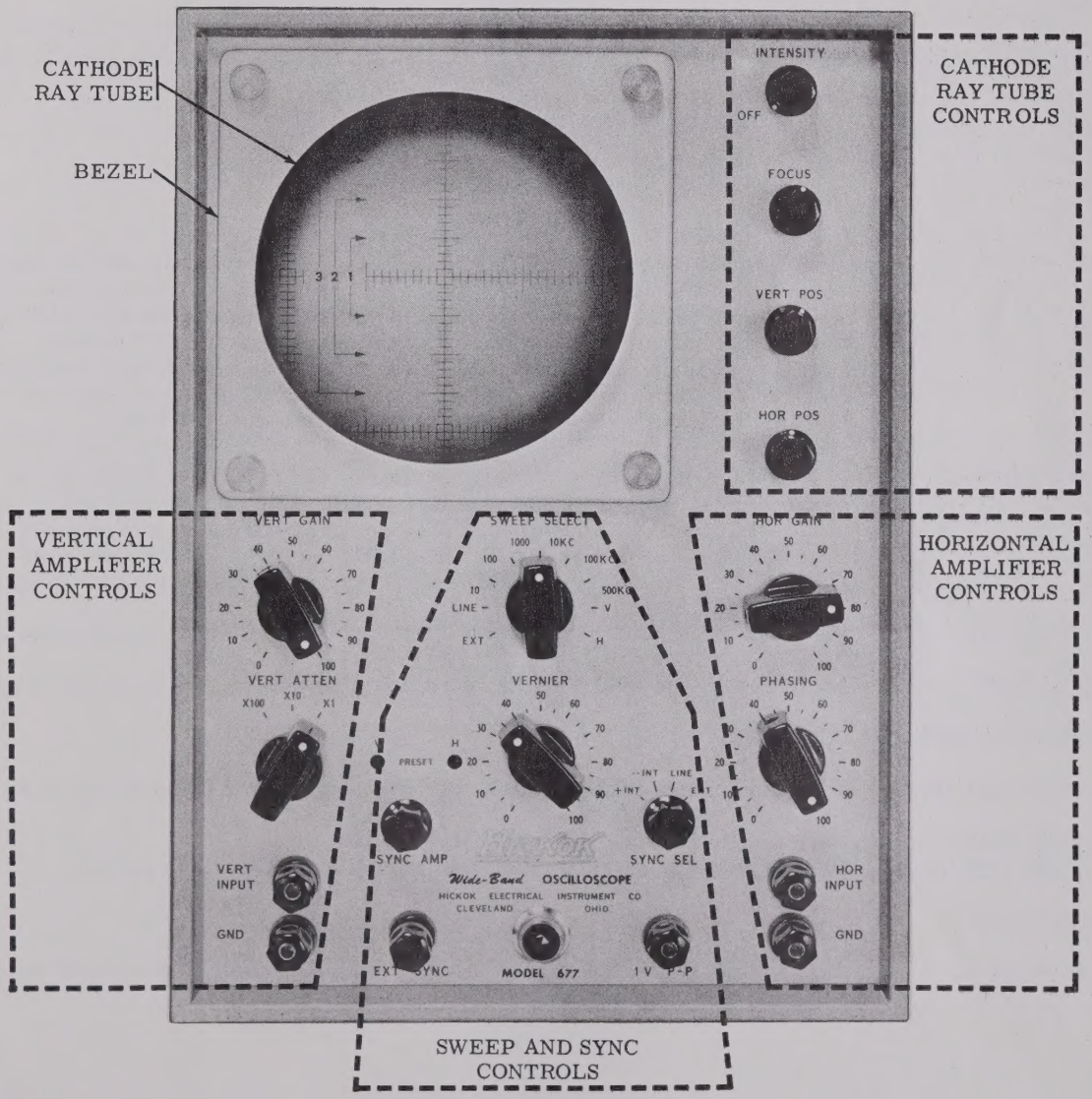


Figure 2-1. FRONT PANEL CONTROLS & CONNECTORS

The location of each control is illustrated in Figure 2-1. Following is an explanation of their function.

a). CATHODE RAY TUBE CONTROLS

1). INTENSITY--- Functions as the on - OFF Switch and permits adjustment of the trace brightness.
2). FOCUS--- Permits adjustment of voltage being applied to the CRT to produce a clearly defined trace.
3). VERT POS--- Variable control to position the trace vertically on the CRT.
4). HOR POS--- Variable control to position the trace horizontally on the CRT.

b). HORIZONTAL AMPLIFIER CONTROLS

1). HOR GAIN--- Variable control to increase or decrease the length of the trace along the horizontal axis.
2). PHASING--- Variable control to adjust the phase of the line frequency being applied to the horizontal amplifier when the SWEEP SELECT switch is in the LINE position. The range of the PHASING control is 180 degrees. The other 180 degree quadrant is obtained by reversing the line plug.
3). HOR INPUT--- Binding post for applying an external signal to the horizontal amplifier.
4). GND--- Binding post to provide a chassis ground connection.

c). SWEEP AND SYNC CONTROLS

1). SWEEP SELECT--- 9 Position switch to select horizontal sweep frequencies in five steps as follows:

10 to 100cps
100 to 1000cps
1KC to 10KC
10KC to 100KC
100KC to 500KC

By setting the SWEEP SELECT switch in the EXT position an external signal may be applied to the horizontal input amplifier. On LINE position a 60 cycle signal is available for horizontal sweep. The V and H positions are used to calibrate the vertical and horizontal amplifier for a steady trace on the CRT screen. The V PRESET is factory adjusted for 30 cycles and can be set for any frequencies between 10 and 100 cycles per second. The H PRESET is factory adjusted for 7.875KC and can be set for any frequency between 1KC and 10KC.

2). VERNIER--- Provides fine adjustment between settings of the SWEEP SELECT switch.
3). SYNC SEL--- Permits selection of four sync settings: +INT, -INT, LINE, and EXT. The +INT and -INT positions determine at what point the waveform will lock with the internally generated sync signal. The LINE position is for sync of 60 cycles or multiples of 60 cycles. The EXT sync position is used when an external sync signal is desired.
4). SYNC AMP--- Permits adjustment of the amount of locking voltage used to synchronize the sweep circuit oscillator.
5). EXT SYNC--- Bindings post for injection of an external sync signal to the horizontal amplifier.

d). VERTICAL AMPLIFIER CONTROLS

1). VERT ATTEN--- 3 Position switch to attenuate the vertical amplitude of the input signal by a factor of ten for each position.
2). VERT GAIN--- Permits adjustment of the vertical amplifier gain.
3). VERT INPUT--- Binding post for injection of an input signal to the vertical amplifier.

e). CONNECTORS

1). 1V P-P--- Binding post connection supplys a fixed voltage of 1 volt peak-to-peak for calibrating the vertical amplifier.

2-2. SEQUENCE OF OPERATION

To place the Model 677 in operation proceed as follows:

a). Connect Instrument to 115 volt, (±10%), 60 cps source.
b). Turn power switch (INTENSITY control) to the "on" position.
c). Set SYNC SEL switch to +INT position.
d). Set SWEEP SELECT switch to desired frequency range.
e). Set HOR POS and VERT POS controls to approximate mid-range.
f). Adjust FOCUS and INTENSITY controls for a sharply defined trace of suitable brightness.
g). Adjust VERT GAIN and HOR GAIN controls for desired deflection of the trace.
h). Further control settings are dependent on specific application.

CAUTION

To prevent burning of the phosphorescent coating on the face of the CRT, avoid stationary spot exposure of high intensity.

2-3. SPECIFIC APPLICATION

a). Vertical Amplifier Calibration--- To calibrate the vertical amplifier, connect a jumper between 1V P-P terminal and the VERT INPUT terminal. Set the VERT GAIN control and the VERT ATTEN for the desired amplitude. Remove the jumper between the 1V P-P and VERT INPUT. Without readjusting the VERT GAIN and VERT ATTEN controls, apply a signal to the VERT INPUT terminal. The unknown voltage is then the ratio of the amplitude of the unknown voltage to the amplitude of the trace from the 1V P-P signal. For example: If the controls were set for a 2 inch deflection on the 1V P-P signal and the new signal caused a 4 inch deflection, the unknown signal is 2 volts. It should be noted that the oscilloscope must be calibrated for various settings of the VERT GAIN control. With the VERT ATTEN switch in the X1 position, the signal is not attenuated, but fed directly to the vertical amplifier. In the X10 position the signal is attenuated by a factor of ten. In the X100 position the signal is attenuated by a factor of one-hundred.

b). Frequency Measurement--- The pattern created on an oscilloscope when sinewave voltages are applied to both the horizontal and vertical plates is called a Lissajous figure. A large variety of patterns may be obtained depending on the ratio of the frequency applied to the deflection plates. The lissajous figure is useful in the determination of an unknown frequency by comparison with a known frequency. The signal of unknown frequency is applied to the vertical amplifier of the oscilloscope. Signals from a generator capable of precise frequency settings are applied to the horizontal amplifier. If the two frequencies are 90 degrees out of phase and if their frequencies are the same (that is the ratio of their frequencies is 1:1) the resultant pattern is a circle on the screen. However if they are in phase, a straight line would appear on the screen.

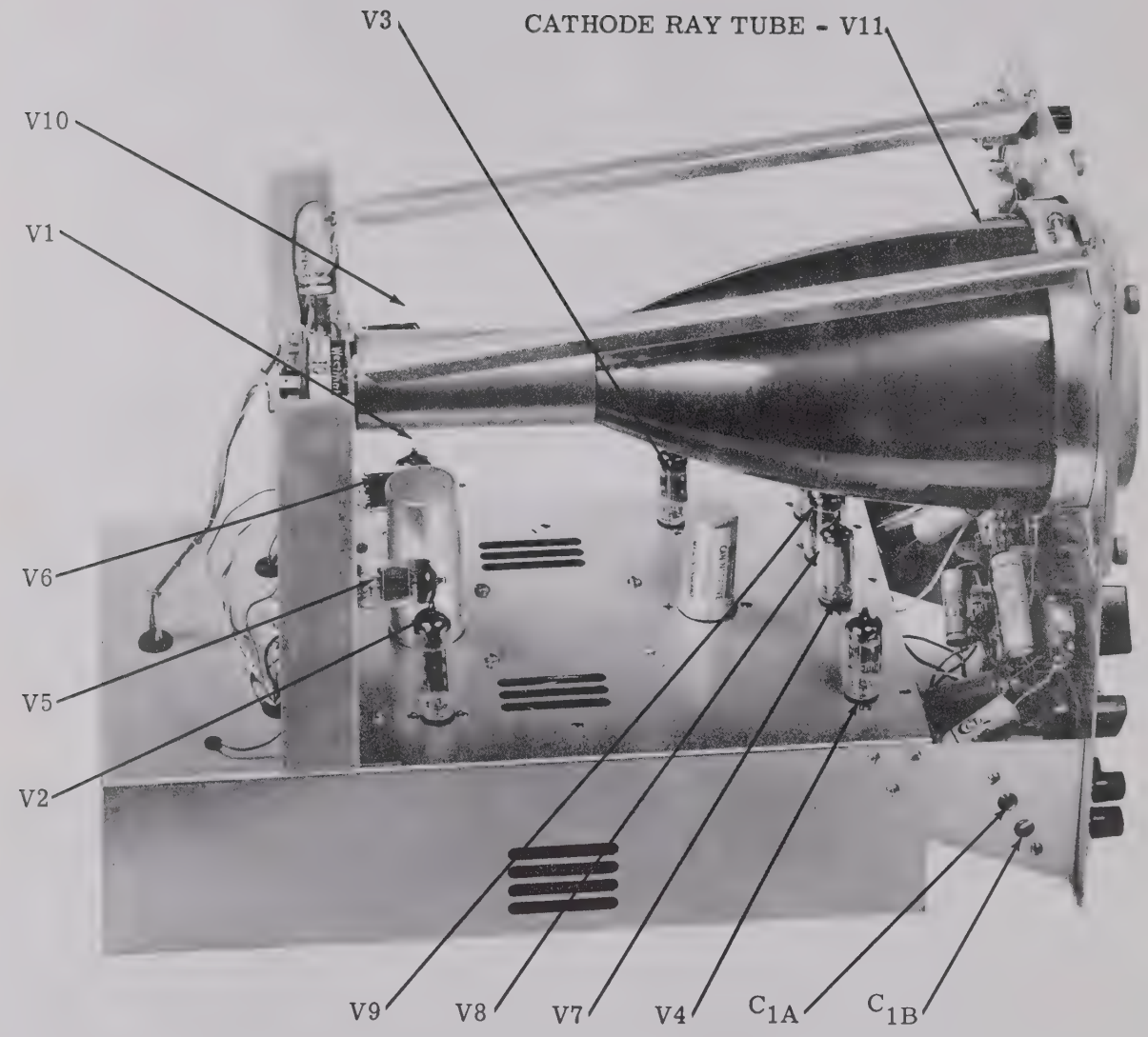


Figure 3-1. TUBE LAYOUT

SECTION 3

CIRCUIT DESCRIPTION

3-1. GENERAL

The circuitry of the Model 677 consists of five (5) functional sections as follows:

a). Low Voltage Power Supply
b). High Voltage Power Supply
c). Vertical Amplifier
d). Horizontal Amplifier
e). Sweep Generator

The Block diagram (Figure 3-2) illustrates the circuitry in block form; the tube layout (Figure 3-1) shows the location of tubes; the table of voltage and resistance values (Figure 3-3) accompanies the schematic wiring diagram (Figure 3-4) in the rear of this manual.

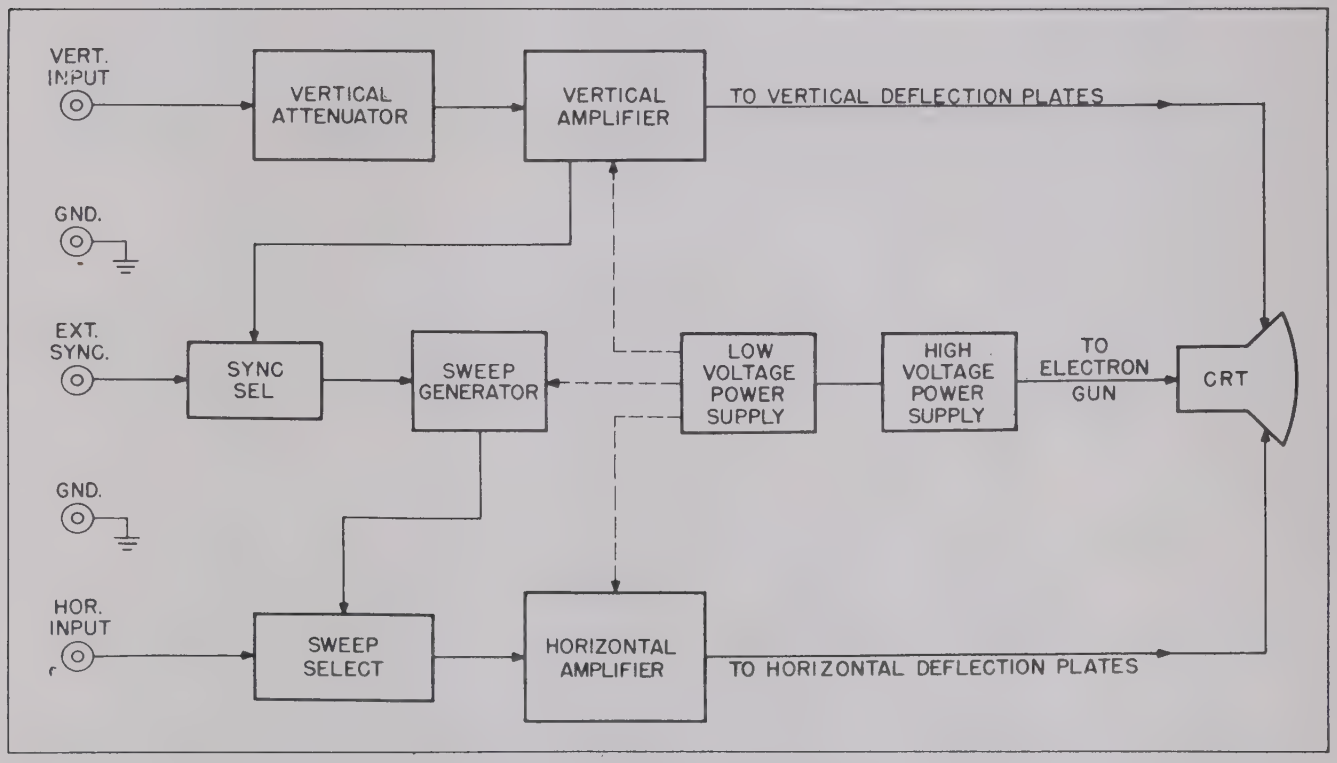


Figure 3-2. BLOCK DIAGRAM

3-2. LOW VOLTAGE POWER SUPPLY

The low voltage power supply consists of a full-wave rectifier and a voltage regulator. The output from the rectifier is fed to the regulator, V3, which in turn regulates the output. The voltage regulator has three (3) regulated outputs; 150 volts for the horizontal amplifier, vertical amplifier, and the sync stage; 390 volts for the cathode ray tube; and 400 volts for the sweep generator.

3-3. HIGH VOLTAGE POWER SUPPLY

The high voltage power supply consists of a half-wave rectifier, that supplies the cathode ray tube with 1300 volts for the accelerating anode. It also provides operating potentials for proper focusing and intensity.

3-4. VERTICAL AMPLIFIER

The vertical amplifier consists of a cathode follower, a vertical input amplifier, and a vertical output amplifier. The purpose of the vertical amplifier is to amplify the signal applied to the VERT INPUT terminal for display on the CRT.

The circuitry of the VERT ATTEN switch attenuates the signal that is applied to the VERT INPUT terminals. The attenuation of the signal depends on the setting of the VERT ATTEN switch. This attenuated signal is applied to V4 (the input cathode follower). The output of V4 is DC coupled to the control grid of V5A (vertical input amplifier). The amount of the voltage applied to the input amplifier is determined by the setting of the VERT GAIN control (R8). The amplified signal from the plate of V5B (which is out of phase with the input) is fed to the grid of V6A. The signal from the cathode of V5B is in phase with the input signal applied to the grid of V6B. Here the even harmonics are cancelled out and the hum in both plate circuits is balanced out. Capacitor (C38) provides the necessary frequency compensation to obtain optimum frequency response for wide-band operation. The output from the push-pull amplifier (V6) is fed through peaking coils L4 and L7, to the vertical defection plates for display on the CRT.

3-5. HORIZONTAL AMPLIFIER

The horizontal amplifier consists of a cathode follower; a horizontal input amplifier; and a horizontal output amplifier. The function of the horizontal amplifier is to amplify and pass a sawtooth voltage to achieve a linearly changing voltage on the CRT horizontal deflection plates. This characteristic is very important because the fly back time of the sawtooth is of extremely short duration. The horizontal amplifier has sufficient bandwidth so that the output of the sweep generator is not distorted.

With the SWEEP SELECT switch in the EXT position, a signal at the HOR INPUT terminals is applied to the grid of the input cathode follower (V9A). The cathode output from this tube is applied to the HOR GAIN control (R47), which is used to vary the applied voltage to the grid of the horizontal input amplifier (V9B). The horizontal input amplifier has both plate and cathode outputs. The $\underline{\text{plate}}$ output of V9A and the $\underline{\text{plate}}$ output of V9B are series connected and AC coupled to the grid of the horizontal output amplifier (V10A). The cathode output of V9B is AC coupled to the grid of V10B. The horizontal output amplifier (V10) drives the horizontal deflection plates of the CRT for horizontal display.

3-6. SWEEP GENERATOR

The sweep generator consists of a sweep multivibrator and a sweep output stage. The function of the sweep generator circuit is to move the electron beam in a continuous sweep across the CRT to establish a reference of time. The output from the sweep generator (V7 and V8A) is a sawtooth waveform, which when applied to the horizontal deflection plates will cause the electron beam to move from left to right at a speed determined by the setting of the SWEEP SELECT switch.

SECTION 4

MAINTENANCE

4-1. OPERATIONAL MAINTENANCE

Before placing the Model 677 into operation, visually inspect it for any physical damage such as broken or cracked knobs, cracked or broken cathode ray tube, etc. All damage claims must be made to the carrier within 48 hours of receipt of the equipment. A damage report sheet is included in the rear of this manual giving detailed instructions for filing a damage report.

The Model 677 is an accurate and precise test instrument. Since it has been thoroughly inspected at the factory, no maintenance is required other than good housekeeping practices. Figure 4-1, Periodic Table of Maintenance, is columnarized to show the components for inspection, the time interval between inspections and what to check in keeping the oscilloscope in good operating condition.

WARNING

EXERCISE CARE WHEN REMOVING OR REPLACING THE CRT. A DANGEROUS IMPLOSION MAY RESULT IF TUBE IS HANDLED CARELESSLY

COMPONENT	TIME	CHECK FOR
Entire Scope	Monthly	General cleanliness, mechanical ridgidity, and stability.
Resistors	Monthly	Charred and blistered condition, discoloration, loose or broken leads.
All Wiring	Monthly	Loose connections, insulation breakdown.
Tubes	Monthly	Filaments lighted, looseness in sockets.
Electrolytic	Monthly	Leaking or encrusted electrolyte.
Capacitors	Monthly	Discoloration, bulging containers.
Power Transformer	Monthly	Discolored or charred case, burnt odor, oozing sealent.
Power Lamp	Monthly	Lights when INTENSITY is turned on.
Power Cable	Monthly	Insulation breakdown, cuts, fraying.
Dials and Controls	Monthly	Freedom of movement (tap controls lightly to check for cut-out due to loose contacts).
Paper and Mica Capacitors	Monthly	Melting containers, wax oozing from ends
Potentiometers	Semi-Annually	Freedom of movement, burn outs, loose connections, broken terminals.

Figure 4-1. PERIODIC TABLE OF MAINTENANCE

4-2. ADJUSTMENTS AND CALIBRATION STANDARDS

Since the Model 677 is factory calibrated and adjusted, no deviation from factory standards may be expected. If, after repairs, a routine calibration is necessary, the following outline will aid in calibration.

a). TEST EQUIPMENT

Calibration requires the following equipment or the equivalent.

1). Hickok Model 1715 Square Wave Generator.
2). Hickok Model 470A Vacuum Tube Volt Meter.
3). Non-Metallic Screwdriver.

b). CALIBRATION PROCEDURE

Set the controls as follows:

1). Set FOCUS and INTENSITY controls for proper brightness and clearness of trace.
2). Adjust VERT POS and the HOR POS controls, to center the trace on the CRT screen.
3). Adjust VERT and HOR GAIN controls for the desired amplitude of trace.
4). Set SWEEP SELECT to 10KC.
5). Adjust SYNC AMP and VERNIER controls to lock a steady pattern on the CRT.
6). Set SYNC SEL to +INT position.
7). Apply a 10KC square wave to the VERT INPUT terminal.
8). Set the VERT ATTEN to X10 Position.

Adjust the output of the square wave generator and the VERT GAIN control (of the Model 677) for approximately two inches of deflection. Using a non-metallic screwdriver, adjust C1A (Figure 3-1) to produce a square wave with minimum distortion. See Figure 4-2A, for the correct waveshape.

9). Set the VERT GAIN to the X100 position.
10). Adjust the output of the square wave generator for approximately a two inch deflection.
11). Adjust C1B, (Figure 3-1) until the square wave shows minimum distortion. See Figure 4-2A.

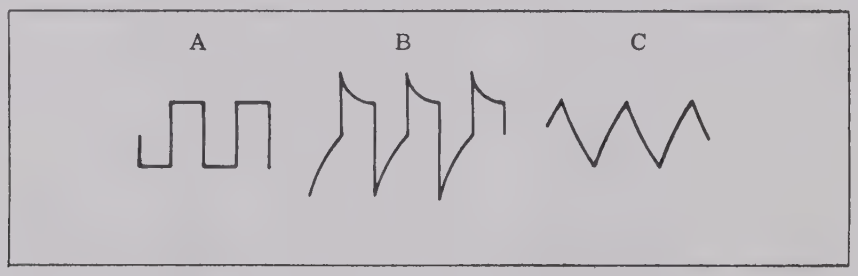


Figure 4-2. SQUARE WAVE ADJUSTMENT

Figure 4-2A represents proper adjustment, while Figure 4-2B represents over-compensation and Figure 4-2C, under compensation.

If a square wave generator is not available, the following method will give a good approximation of correct frequency compensation.

Turn the INTENSITY control to the OFF position. Temporarily solder a wire to the ungrounded side of the HOR GAIN control (R47), and connect the other end to the VERT INPUT binding post.

Set the controls as follows:

a). SWEEP SELECT, switch to the 1000 to 10KC position.
b). VERNIER control to zero.
c). VERT ATTEN switch to X100.
d). VERT GAIN control to 10.
e). Turn the INTENSITY control on.
f). Adjust the FOCUS, INTENSITY, VERT POS, HOR POS and the HOR GAIN control to obtain one of the diagonal lines illustrated in Figure 4-3A, B, or C. It may be necessary to reduce the VERT GAIN control to decrease the amplitude of the diagonal line on the CRT.

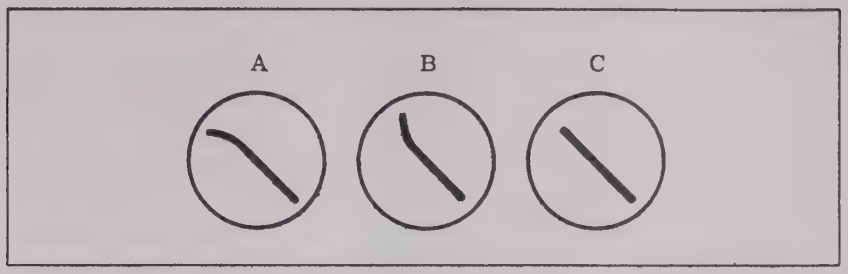


Figure 4-3. COMPENSATION FOR THE VERTICAL ATTENUATOR

With a non-metallic screwdriver, adjust the C1B (Figure 3-1) to obtain the straight line pattern of Figure 4-3C.

Set the VERT ATTEN switch to the X10 position and adjust the VERT GAIN control to obtain a diagonal line of desired length. With a non-metallic screwdriver, adjust C1A, (Figure 3-1), until a straight line appears on the CRT, as in Figure 4-3C. Turn the oscilloscope power-off, and remove the temporarily soldered wire.

The physical shape of the trace may be adjusted by R28, the spot shape control. If it is desirable to adjust the spot shape, the control is easily accessible through the rear panel.

SECTION 5

PARTS LIST

5-1. INTRODUCTION

Reference designations are assigned to identify all parts of the Model 677. These designations are used in the parts list and schematic wiring diagram. The letter prefix of a reference designation indicates the kind of part--resistor, capacitor, electron tube, etc. The number differentiates between parts in the same group.

Table 5-1. PARTS LIST

REF. DESIG.	NOTES	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
C1A		CAPACITOR, TRIMMER, DUAL: 2.7 - 30 pf	3115-47	.80
C1B		CAPACITOR, TRIMMER, DUAL: 50 - 380 pf	3115-47	1.15
C2		CAPACITOR, FIXED, CERAMIC: 47 pf, 600 volts	3110-193	.15
C3		CAPACITOR, FIXED, CERAMIC: 390pf, 600 volts	3110-196	.15
C4		CAPACITOR, FIXED: 0.1uf, 600 volts	3105-155	.15
C5		CAPACITOR, FIXED, ELECTROLYTIC: 100uf, 50 volts	3085-127	.85
C6		CAPACITOR, FIXED: 0.1uf, 400 volts	3105-179	.15
C7		CAPACITOR, FIXED, ELECTROLYTIC, 20uf, 150 volts	3085-134	.65
C8		Same as C6		
C9		CAPACITOR, FIXED, CERAMIC: 1000pf, 10%, 1000 volts	3110-192	.15
C10		Same as C6		
C11		CAPACITOR, FIXED, CERAMIC: 0.01uf, 600 volts	3110-189	.20
C12		CAPACITOR, FIXED: 0.05uf, 600 volts	3105-211	.25
C13		Same as C2		
C14		CAPACITOR, FIXED: 0.01uf, 400 volts	3105-177	.15
C15		CAPACITOR, FIXED: 0.05uf, 400 volts	3105-175	.20
C16		Same as C14	3105-175	.20
C17		CAPACITOR, FIXED, CERAMIC: 0.02uf, 1600 volts	3110-195	.30
C18		CAPACITOR, FIXED: 0.25uf, 400 volts	3105-173	.30
C19		CAPACITOR, CERAMIC DISC: 0.02uf, 600 volts	3110-183	.25
C20		CAPACITOR, FIXED, CERAMIC: 0.002uf, 600 volts	3110-190	.15
C21		CAPACITOR, FIXED, CERAMIC: 220pf, 600 volts	3110-194	.15
C22		CAPACITOR, FIXED, CERAMIC: 20pf, 10%, 600 volts	3110-197	.15
C23		CAPACITOR, FIXED: 0.2uf, 400 volts	3105-99	.30
C24		Same as C20		
C25		Same as C18		
C26		Same as C7		
C27		CAPACITOR, FIXED: 500pf, 20%, 600 volts	3110-191	.30
C28		Same as C6		
C29		Same as C6		
C30A, B, C		CAPACITOR, FIXED, ELECTROLYTIC: 3 sections, 20x20x20uf, 250 volts	3085-196	2.15
C31A, B, C, D		CAPACITOR, FIXED, ELECTROLYTIC: 4 sections, 40x40x20x20uf, 450 volts	3085-195	3.00
C32		Not assigned		
C33		Same as C18		
C34		Same as C15		
C35		Same as C14		
C36		CAPACITOR, FIXED: 0.25uf, 1600 volts	3105-362	.35
C37		CAPACITOR, FIXED: 0.1uf, 1600 volts	3105-363	.35
C38		CAPACITOR, VARIABLE, CERAMIC: 3-12pf	3115-40	.80

REF. DESIG.	NOTES	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
DS1		LAMP: #47 G. E., 6-8 volts	12270-12	.10
F1		FUSE: 3AG, 2 amp	6900-2	.10
F2		Same as F1		
L1		COIL: peaking, 61mh	3320-313	1.00
L2		Same as L1		
L3		COIL: peaking, 30mh	3320-312	1.00
L4		COIL: peaking, 33mh	3320-314	1.00
L5		COIL: peaking, 90mh	3320-315	1.00
L6		Same as L5		
L7		Same as L4		
R1		RESISTOR, FIXED, COMPOSITION: 3.3 megohms, 5%, 1/2 watt	18415-331	.25
R2		RESISTOR, FIXED, COMPOSITION: 330K ohms, 5%, 1/2 watt	18414-331	.25
R3		RESISTOR, FIXED, COMPOSITION: 36K ohms, 5%, 1/2 watt	18413-361	.25
R4		RESISTOR, FIXED, COMPOSITION: 3.3 megohms, 10%, 1/2 watt	18415-332	.10
R5		RESISTOR, FIXED, COMPOSITION: 100 ohms, 10%, 1/2 watt	18411-102	.10
R6		RESISTOR, FIXED, COMPOSITION: 560 ohms, 10%, 1/2 watt	18411-562	.10
R7		RESISTOR, FIXED, COMPOSITION: 3.3K ohms, 10%, 1/2 watt	18412-332	.10
R8		POTENTIOMETER, COMPOSITION: 2K ohms, 10%, 1/2 watt	16925-379	1.00
R9		RESISTOR, FIXED, COMPOSITION: 10 megohms, 10%, 1/2 watt	18416-102	.10
R10		RESISTOR, FIXED, COMPOSITION: 2.2K ohms, 10%, 1/2 watt	18412-222	.10
R11		Same as R7		
R12		RESISTOR, FIXED, COMPOSITION: 470K ohms, 10%, 1/2 watt	18414-472	.10
R13		Same as R10		
R14		Same as R5		
R15		RESISTOR, FIXED, COMPOSITION: 100K ohms, 10%, 1/2 watt	18414-102	.10
R16		POTENTIOMETER, COMPOSITION: 20K ohms, with center tap, 10%, 1/2 watt	16925-477	.10
R17		RESISTOR, FIXED, COMPOSITION: 33K ohms, 10%, 1/2 watt	18413-332	.10
R18		RESISTOR, FIXED, COMPOSITION: 3.3 megohms, 10%, 1 watt	18425-332	.20
R19		Same as R5		
R20		Same as R5		
R21		RESISTOR, FIXED, COMPOSITION: 1.2K ohms, 10%, 2 watt	18432-122	.25
R22		RESISTOR, FIXED, COMPOSITION: 3.3K ohms, 10%, 2 watt	18432-332	.25
R23		RESISTOR, FIXED, COMPOSITION: 1K ohm, 10%, 1 watt	18422-102	.20
R24		Same as R23		
R25		Same as R22		
R26		Same as R7		
R27		Same as R7		
R28		POTENTIOMETER, COMPOSITION: 1 megohm, 10%, 1/2 watt	40500-105	.50
R29		POTENTIOMETER, COMPOSITION: 50K ohms, 10%, 1/2 watt	16925-473	1.00
R30		Same as R12		
R31		RESISTOR, FIXED, COMPOSITION: 15K ohms, 10%, 1/2 watt	18413-152	.10

REF. DESIG.	NOTES	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
R32		RESISTOR, FIXED, COMPOSITION: 22K ohms, 10%, 1/2 watt	18413-222	.10
R33		Same as R9		
R34		RESISTOR, FIXED, COMPOSITION: 2.2 megohms, 10%, 1/2 watt	18415-222	.10
R35		RESISTOR, FIXED, COMPOSITION: 100K ohms, 10%, 1 watt	18424-102	.20
R36		POTENTIOMETER, COMPOSITION: 2 megohms, 10%, 1/2 watt	16925-472	.50
R37		Same as R36		
R38		RESISTOR, FIXED, COMPOSITION: 68K ohms, 10%, 1/2 watt	18413-682	.10
R39		RESISTOR, FIXED, COMPOSITION: 150K ohms, 10%, 1/2 watt	18414-152	.10
R40		Same as R38		
R41		POTENTIOMETER, COMPOSITION: 2 megohms, 10%, 1/2 watt	16925-475	1.00
R42		RESISTOR, FIXED, COMPOSITION: 4.7 megohms, 10%, 1/2 watt	18415-472	.10
R43		Same as R10		
R44		Same as R32		
R45		Same as R10		
R46		RESISTOR, FIXED, COMPOSITION: 47K ohms, 10%, 1/2 watt	18413-472	.10
R47		Same as R29		
R48		RESISTOR, FIXED, COMPOSITION: 1K ohm, 10%, 1/2 watt	18412-102	.10
R49		Same as R32		
R50		Same as R4		
R51		POTENTIOMETER, COMPOSITION: 200K ohms, 10%, 1/2 watt	16925-476	1.35
R52		Same as R5		
R53		Same as R5		
R54		RESISTOR, FIXED, COMPOSITION: 10K ohms, 10%, 2 watt	18433-102	.25
R55		RESISTOR, FIXED, COMPOSITION: 27K ohms, 10%, 1 watt	18423-272	.20
R56		Same as R55		
R57		RESISTOR, FIXED, COMPOSITION: 1.5K ohms, 10%, 1 watt	18422-152	.20
R58		RESISTOR, FIXED, COMPOSITION: 3.9K ohms, 10%, 1/2 watt	18412-392	.10
R59		Same as R58		
R60		Same as R58		
R61		RESISTOR, FIXED, COMPOSITION: 18K ohms, 10%, 1/2 watt	18413-182	.10
R62		Same as R4		
R63		RESISTOR, FIXED, COMPOSITION: 1 megohm, 10%, 1/2 watt	18415-102	.10
R64		Same as R41		
R65		POTENTIOMETER, COMPOSITION: 500K ohms, 10%, 1/2 watt	16925-474	1.50
R66		Same as R12		
R67		Same as R15		
R68		RESISTOR, FIXED, COMPOSITION: 220 ohms, 10%, 1/2 watt	18411-222	.10
R69		RESISTOR, WIRE WOUND: 5K ohms, 10%, 10 watt	18575-258	.35
R70		RESISTOR, FIXED, COMPOSITION: 4.7K ohms, 10%, 2 watt	18432-472	.25
R71		RESISTOR, WIRE WOUND: 1K ohm, 10%, 7 watt	18575-437	.50
R72		RESISTOR, FIXED, COMPOSITION: 220K ohms, 10%, 1 watt	18424-222	.20

REF. DESIG.	NOTES	NAME AND DESCRIPTION	HICKOK PART NO.	PRICE EACH
R73		Same as R12		
R74		RESISTOR, FIXED, COMPOSITION: 470 ohms, 10%, 1/2 watt	18411-472	.10
R75		RESISTOR, FIXED, COMPOSITON: 62 ohms, 10%, 1/2 watt	18410-622	.10
R76		POTENTIOMETER, COMPOSITION: 250K ohms, 10%, 1/2 watt	16925-478	1.00
R77		RESISTOR, FIXED, COMPOSITION: 1 megohm, 10%, 1 watt	18425-102	.20
R78		RESISTOR, FIXED, COMPOSITION: 10K ohms, 10%, 1/2 watt	18413-102	.10
R79		Same as R48		
S1		SWITCH: rotary, 1 deck, 3 position, vertical attenuator	19912-543	1.00
S2		SWITCH: rotary, 1 deck, 4 position, sync selector	19912-544	1.25
S3		SWITCH: rotary, 1 deck, 9 position, sweep selector	19912-545	2.00
T1		TRANSFORMER, POWER	20800-295	12.00
V1		TUBE, ELECTRON: 1V2	20875-86	2.10
V2		TUBE, ELECTRON: 6x4	20875-68	1.65
V3		TUBE, ELECTRON: 6C4	20875-62	1.85
V4		Same as V3		
V5		TUBE, ELECTRON: 6AN8	20875-129	4.00
V6		TUBE, ELECTRON: 12BH7	20875-124	3.05
V7		TUBE, ELECTRON: 6DT6	20875-235	2.15
V8		TUBE, ELECTRON: 12AU7	20875-69	2.45
V9		Same as V8		
V10		Same as V8		
V11		TUBE, CATHODE RAY: 5UP1	20875-67	21.60
		BOOKLET: Instructions	2490-469	

NOTE: A minimum billing charge of $3.50 will be assessed for any parts order. Prices are subject to change without notice.

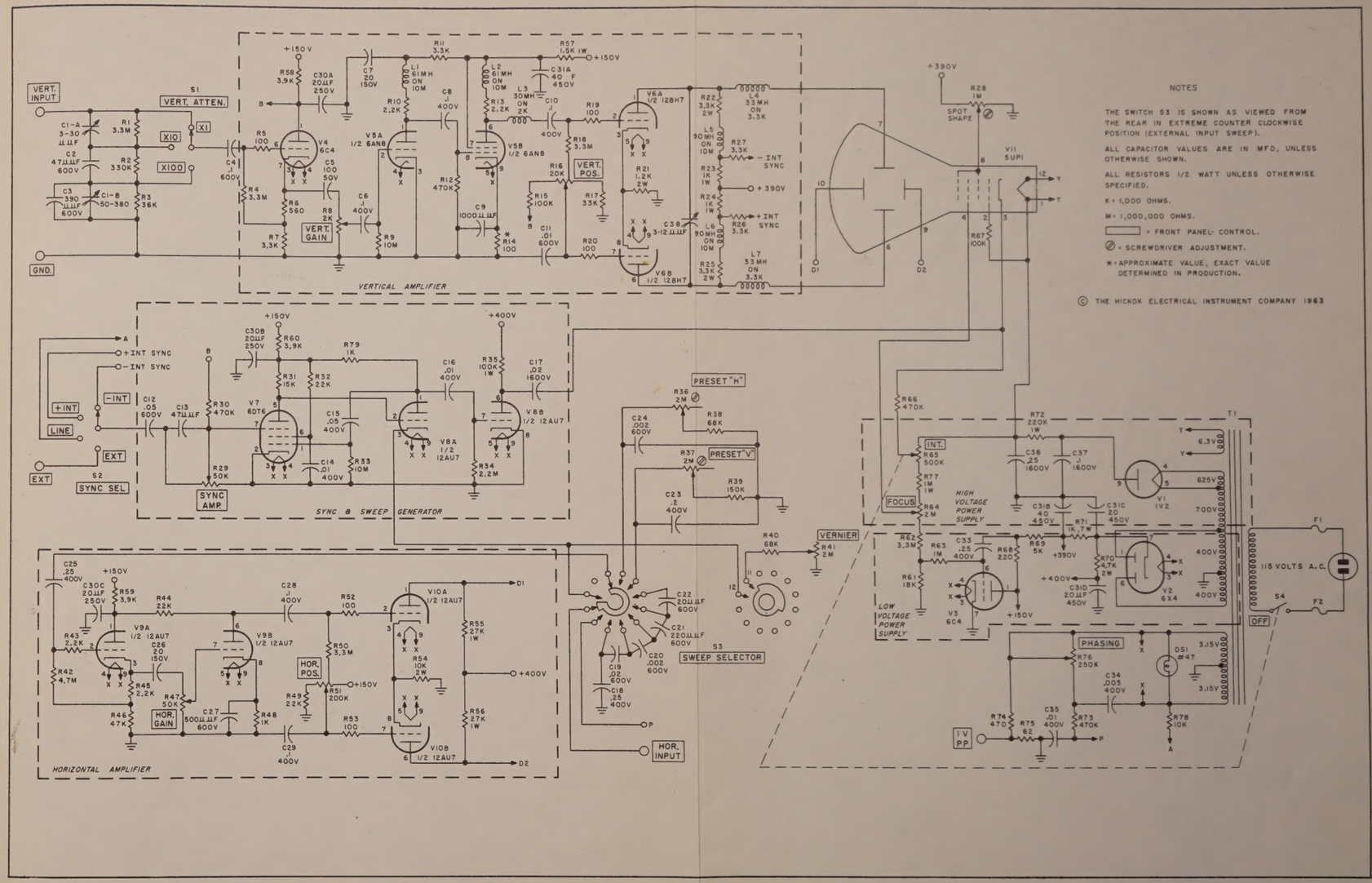
All voltage readings taken with respect to ground and taken with a 10KC square wave applied to the VERT INPUT terminal with the controls set as follows:

a). HOR GAIN---25
b). SWEEP SELECT---10-100 cycles
c). VERT GAIN---50
d). VERT ATTEN---X1
e). VERNIER---25
f). PHASING---zero
g). SYNC AMP---Mid Range or Lock Trace on CRT
h). SYNC SEL---+INT

Tube		Voltage Readings at Pin Numbers											
Sym	Type	1	2	3	4	5	6	7	8	9	10	11	12
V1	1V2	NC	NC	NC	1120ac	1120ac	NC	NC	NC	-1.3kvac			
V2	6X4	400ac	NC	3.15ac	3.15ac	NC	400ac	430ac					
V3	6C4	150ac	NC	3.15ac	3.15ac	NC	-4.2ac	-0-					
V4	6C4	133	NC	3.15ac	3.15ac	NC	17.5	22.5					
V5	6AN8	75	-1.2	-0-	3.15ac	3.15ac	105	123	-0-	1.5			
V6	12BH7	410	41	41	3.15ac	3.15ac	320	38	42	3.15ac			
V7	6DT6	-1.25	-0-	3.15ac	3.15ac	110	90	-0-					
V8	12AU7	134	100	110	3.15ac	3.15ac	41	-0-	-0-	3.15ac			
V9	12AU7	130	44	60	3.15ac	3.15ac	75	-0.2	2.4	3.15ac			
V10	12AU7	360	80	100	3.15ac	3.15ac	410	80	100	3.15ac			
V11	5UP1	-1.3kv	-1.3kv	-1.3kv	-900	NC	300	370	300	375	250	NC	-1.3kv

Tube		Resistance Values at Pin Numbers with Respect to Ground											
Sym	Type	1	2	3	4	5	6	7	8	9	10	11	12
V1	1V2	NC	NC	NC	300	300	NC	NC	NC	7M			
V2	6X4	300	NC	-0-	-0-	NC	300	70K					
V3	6C4	70K	NC	-0-	-0-	NC	1.2M	-0-					
V4	6C4	80K	NC	-0-	-0-	NC	4M	4K					
V5	6AN8	75K	9.4M	-0-	-0-	-0-	88K	75K	500K	120			
V6	12BH7	1.2K	4M	1.2K	-0-	-0-	10K	42K	1.3K	-0-			
V7	6DT6	10.5M	-0-	-0-	-0-	100K	90K	19K					
V8	12AU7	75K	90K	65K	-0-	-0-	200K	2.2M	-0-	-0-			
V9	12AU7	85K	5M	42K	-0-	-0-	100K	.2	1K	-0-			
V10	12AU7	50K	5M	12K	-0-	-0-	55K	65K	11K	-0-			
V11	5UP1	6.3M	6M	6.4M	4.25M	NC	88K	80K	200K	115K	110K	NC	6.3M

Figure 3-3. TABLES OF VOLTAGE AND RESISTANCE VALUES


VERTICAL AMPLIFIER
SYNC & SWEEP GENERATOR
HORIZONTAL AMPLIFIER
HIGH VOLTAGE POWER SUPPLY
LOW VOLTAGE POWER SUPPLY
SWEEP SELECTOR
VERNIER
NOTES
THE SWITCH S3 IS SHOWN AS VIEWED FROM THE REAR IN EXTREME COUNTER CLOCKWISE POSITION (EXTERNAL INPUT SWEEP).
ALL CAPACITOR VALUES ARE IN MFD, UNLESS OTHERWISE SHOWN.
ALL RESISTORS 1/2 WATT UNLESS OTHERWISE SPECIFIED.
K = 1,000 OHMS.
M = 1,000,000 OHMS.
= FRONT PANEL CONTROL.
= SCREWDRIVER ADJUSTMENT.
* = APPROXIMATE VALUE, EXACT VALUE DETERMINED IN PRODUCTION.
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115 VOLTS A.C.

Figure 3-4. SCHEMATIC WIRING DIAGRAM